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ABSTRACT

Presented are the results of a survey of over 100,000 manufacturing establishments, conducted for the National Science Foundation by the Bureau of Labor Statistics, covering average annual employment for calendar year 1977. Industries whose relative concentration of scientists and engineers was high in 1977, such as petroleum refining, chemicals, and electrical equipment, grew at a significantly faster rate, measured by total employment, than industries with low concentrations, such as apparel, leather products, and printing and publishing. High concentration industries showed total employment gains of 17% from 1965 to 1977, and 4% from 1970 to 1977. Industries with low concentrations grew at rates of 4% from 1965 to 1977 and showed a slight employment decline from 1970 to 1977. (Author/BB)

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SCIENCE RESOURCES STUDIES

HIGHLIGHTS

NATIONAL SCIENCE FOUNDATION • WASHINGTON, D. C. 20550 • APRIL 20, 1979 • NSF 79-307

Manufacturing Industries with High Concentrations of Scientists and Engineers Lead in 1965-77 Employment Growth

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

The results discussed below are based on a survey of over 100,000 manufacturing establishments conducted for the National Science Foundation by the Bureau of Labor Statistics covering average annual employment for calendar year 1977. These data are the most detailed available industry and occupation information on employment of scientists, engineers, and technicians (SE&T) in the manufacturing sector. Subsequent surveys will cover other sectors of the economy.

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Assessment Highlights

- Industries whose relative concentration of scientists and engineers was "high" in 1977—such as petroleum refining, chemicals, and electrical equipment—grew at a significantly faster rate, measured by total employment, than industries with "low" concentrations—such as apparel, leather products, and printing and publishing. High-concentration industries showed total employment gains of 17 percent from 1965 to 1977, and 4 percent from 1970 to 1977. Industries with low concentrations grew at rates of 4 percent from 1965 to 1977 and showed a slight employment decline from 1970 to 1977.
- Over 70 percent of the scientists and engineers in manufacturing were employed in industries whose total employment growth from 1965 to 1977 exceeded the average for all manufacturing industries. Less than 7 percent were employed in industries which showed declining employment in this period. Scientists and engineers were thus well placed to participate in growing industries.

Data Highlights

- Almost 6 percent of all employees in manufacturing establishments in 1977 were scientists, engineers, and technicians. Manufacturing industries employed 127,000 scientists, 515,000 engineers, and 493,000 technicians.
- The largest groups of employed engineers were electrical and electronic, 142,000; mechanical, 113,000; industrial, 65,000; and aeronautical, 37,000.
- Electrical equipment, transportation equipment, and machinery industries were, in that order, the largest employers of scientists and engineers.

- Two-thirds of all technicians were employed in the machinery, electrical equipment, transportation equipment, and chemicals industries.

Employment by Industry

When tabulated by industry, the three largest users of science and engineering (S/E) talent were electrical equipment, transportation equipment, and machinery (table 1). The chemical industry used more scientists than the next five largest scientist-using industries combined.

There were 493,000 technicians employed in manufacturing industries in 1977—22 percent of them in nondurable goods, and 78 percent in durable goods. Industries employing the most technicians were machinery, 118,000; electrical equipment, 103,000; transportation equipment, 57,000; and chemicals, 50,000. As a proportion of S/E employment, the most technician-intensive industry was printing and publishing, closely followed by the furniture industry and food and kindred products, each of which employed about 1.3 technicians for each scientist and engineer. Of the four largest employers of technicians, only the machinery industry employed more than one technician per scientist and engineer.

Employment by Occupation

Of the total 1,135,000 scientists, engineers, and technicians employed in manufacturing in 1977, 127,000 were scientists, 515,000 were engineers, and 493,000 were technicians.

Among the engineering occupations, the most numerous was electrical and electronics engineers, with 142,000 employed (chart 1), representing 28 percent of all engineers. Mechanical (113,000), industrial (65,000), and aeronautical (37,000) were the next largest specified

Table 1: Distribution of scientists, engineers, and technicians in manufacturing industries: 1977
[Numbers in thousands]

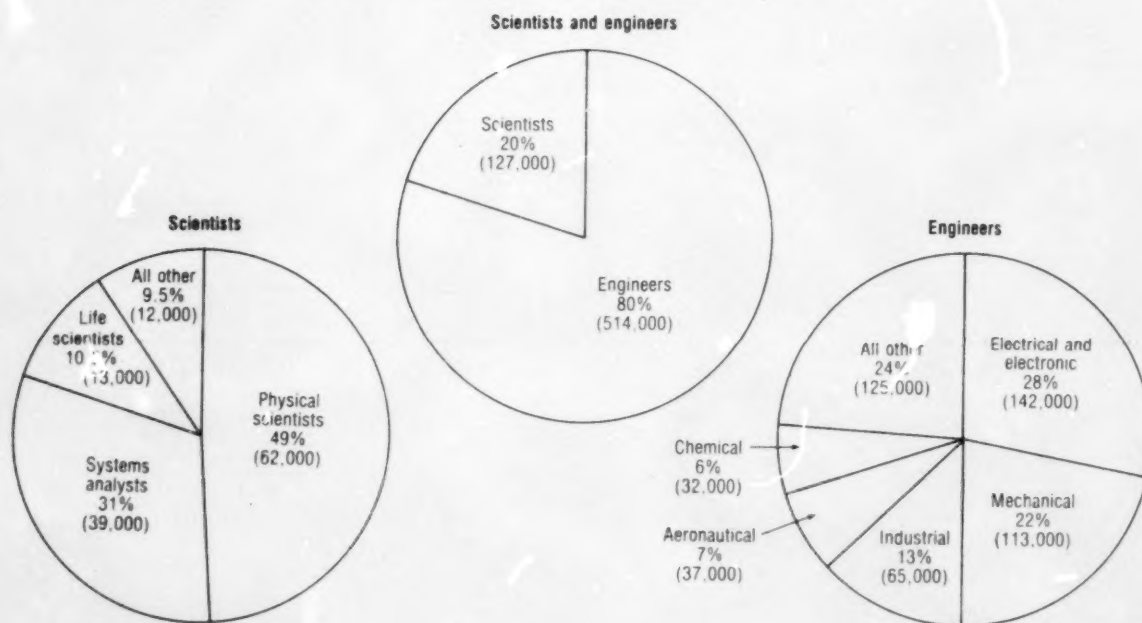
Industry	SIC codes ¹	Scientists and Engineers						Technicians		Technicians per scientist and engineer
		Total		Engineers		Scientists				
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	
Total manufacturing	NA	641.3	100.0	514.5	100.0	126.8	100.0	493.0	100.0	.77
Nondurable goods	NA	157.3	24.5	81.3	15.8	76.0	59.9	109.4	22.2	.70
Food & kindred products	20	10.3	1.6	3.8	.7	6.5	5.1	13.0	2.6	1.26
Tobacco & manufacturers	21	1.5	.2	0.6	.1	1.0	.8	1.8	.4	1.20
Textile	22	6.2	1.0	4.2	.8	1.9	1.5	6.2	1.3	1.00
Apparel	23	3.3	.5	2.8	.5	.4	.3	2.0	.4	.61
Paper and allied products	26	9.6	1.5	6.9	1.3	2.7	2.1	5.8	1.2	.60
Printing and publishing	27	4.2	.7	1.5	.3	2.7	2.1	5.4	1.1	1.29
Chemicals and allied products	28	89.0	13.9	38.6	7.5	50.5	39.8	50.2	10.2	.56
Petroleum refining	29	17.1	2.7	10.5	2.0	6.6	5.2	8.5	1.7	.50
Rubber & plastic products	30	11.4	1.8	8.8	1.7	2.6	2.1	11.6	2.4	1.02
Leather products	31	0.8	.1	0.5	.1	.3	.2	.4	.1	.50
Miscellaneous manufacturing	39	3.9	.6	3.1	.6	.7	.6	4.5	.9	1.15
Durable goods	NA	484.0	75.5	433.2	84.2	50.8	40.0	383.5	77.8	.79
Lumber and wood products	24	2.8	.4	1.6	.3	1.2	1.0	3.3	.7	1.16
Furniture & fixtures	25	2.5	.4	2.2	.4	.3	.2	3.2	.7	1.28
Stone, clay, & glass	32	9.2	1.4	7.1	1.4	2.2	1.7	9.4	1.9	1.02
Primary metals	33	24.6	3.8	20.5	4.0	4.1	3.2	20.0	4.1	.81
Fabricated metal products	34	32.9	5.1	29.3	5.7	3.6	2.8	33.2	6.7	1.01
Machinery	35	107.3	16.7	97.0	18.9	10.3	8.1	117.7	23.9	1.10
Electrical equipment	36	139.0	21.7	126.3	24.6	12.6	9.9	102.7	20.8	.74
Transportation equipment	37	125.1	19.5	113.4	22.0	11.7	9.2	56.8	11.5	.45
Professional & scientific instruments	38	40.7	6.4	35.9	7.0	4.8	3.8	37.2	7.6	.91

¹ Based on 1972 Standard Industrial Classification Manual.

NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation.

Chart 1.—Total scientists and engineers employed in manufacturing industries by occupation: 1977



SOURCE: National Science Foundation

Additional data from this survey will be issued in *Detailed Statistical Tables, Employment of Scientists and Engineers in Manufacturing Industries, 1977* and will be available by early summer from the Division of Science Resources Studies.

groups of engineers, although the "all other engineers group" totaled 125,000.¹

Physical scientists, the largest component of the scientific occupations employed in manufacturing, made up 49 percent of this group. Most of these scientists were chemists (54,000); the next most numerous group of scientists was computer systems analyst, with 39,000 employed.

Concentration and Employment Growth

Since the number of scientists and engineers employed in each industry may be related to the total employment size of that industry, it is useful to go beyond a percentage distribution of scientists, engineers, and technicians (table 1). This is done by computing a concentration ratio for each industry, relating the proportion of scientists and engineers employed in that industry to the proportion of manufacturing employment (chart 2).²

Using this measure of concentration, it becomes evident that the petroleum refining industry utilized almost 2.6 times as many scientists and engineers as would be expected on the basis of its total employment; it employed almost twice the number of engineers, over five times the number of scientists, and almost 1.7 times the number of technicians that it would have if these occupations had been distributed the same as total employment. Other industries with high S/E concentrations were chemicals, electrical equipment, transportation equipment, scientific instruments, and machinery. Concentration ratios of technicians were highest among the scientific instruments, and machinery, and electrical equipment industries.

The relationship between concentrations of S/E employment and growth in total employment is indicated in table 2, which shows the industries ranked in descending order of S/E concentration ratios. They have been grouped into those whose ratios lie above 1.0 (i.e., those which employ proportionally more scientists and engineers than would be expected on the basis of their total employment), and those with ratios below 1.0. Those industries with high-concentration ratios showed a total employment growth of 17 percent between 1965 and 1977, and 4 percent in the 1970-77 period. The industries with low concentrations grew only 4 percent from 1965 to 1977 and actually showed a slight employment decline from 1970 to 1977.

However, this observed tendency toward high S/E concentrations in high-growth industries is not universal. Transportation equipment, for example, is a high-concentration industry, but its employment growth pattern is much closer to the low-concentration group. The reverse is true of several industries in the latter

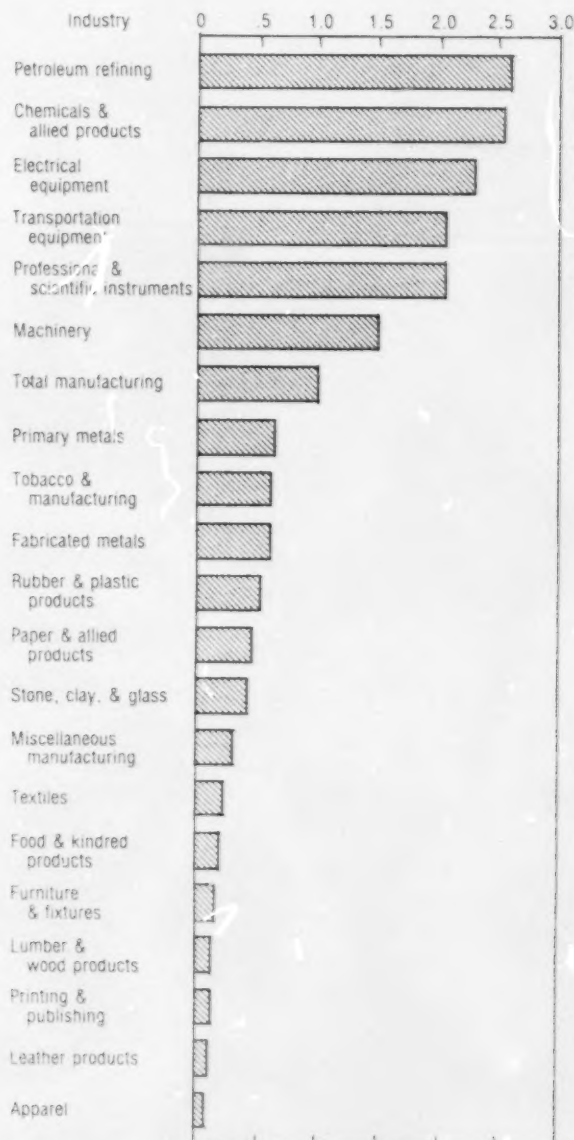
group, including fabricated metals, rubber and plastic products, and printing and publishing.³

Current Employment Estimates

If one is willing to accept the assumption that the skill-mix within industry changes relatively slowly over a short

¹ The simple correlation between concentration and growth was .8887 for 1965-77, as measured by the Pearson correlation coefficient. This coefficient is statistically significant at the 95-percent level of confidence.

Chart 2.—Concentration ratios of scientists and engineers: 1977



SOURCE: National Science Foundation

¹ This group includes some engineers not classified by specialty, as well as automotive, mining, traffic, nuclear, civil, metallurgical, petroleum, ceramic, and safety engineers.

² More formally, $C = \frac{S_i/S}{E_i/E}$ where C is the concentration ratio shown on chart 2, S_i is the number of scientists, engineers, or technicians in industry i, S is the total number of scientists, engineers, or technicians in manufacturing, E_i is the total employment in industry i and E is total manufacturing employment.

Table 2: Relationship of science/engineering concentration to total employment growth: 1965-77

Industry	SIC	Concentration rates, total S/E	Total employment			Percent change	
			In thousands			1965-70	1965-77
			1965	1970	1977		
Above-average concentration	NA	2.035	6,614.8	7,398.4	7,713.7	11.8	16.6
Petroleum refining	29	2.596	182.9	240.8	209.4	4.3	14.5
Chemicals & allied products	28	2.530	907.6	1,049.0	1,057.6	15.6	16.5
Electrical equipment	36	2.270	1,659.2	1,917.0	1,935.5	15.5	16.6
Transportation equipment	37	2.037	1,740.6	1,799.1	1,797.0	3.4	3.2
Professional & scientific instruments	38	2.024	389.0	460.4	527.2	18.4	35.5
Machinery	35	1.518	1,735.3	1,982.1	2,187.0	14.2	26.0
Below average concentration	NA	319	11,220.9	11,708.1	11,686.9	4.3	4.2
Primary metals	33	642	1,801.0	1,315.6	1,204.1	1.1	-7.4
Tobacco & manufactures	21	639	86.8	82.9	69.8	-4.5	-19.6
Fabricated metals	34	637	1,269.0	1,380.4	1,451.6	8.8	14.4
Rubber & plastic products	30	487	470.8	580.1	675.4	23.2	43.4
Paper & allied products	26	431	639.1	705.5	698.9	10.4	9.4
Stone, clay & glass	32	420	628.3	640.2	652.2	1.9	3.8
Miscellaneous manufacturing	39	274	419.7	425.7	418.5	1.5	-2
Textiles	22	209	925.6	975.9	981.9	5.4	6.1
Food & kindred products	20	186	1,756.7	1,782.7	1,719.9	1.5	-2.1
Furniture & fixtures	25	166	430.7	459.8	507.9	6.8	18.4
Lumber & wood products	24	121	606.9	572.7	642.3	-5.6	5.8
Printing & publishing	27	113	979.4	1,101.6	1,109.4	12.5	13.3
Leather products	31	991	352.9	320.4	264.3	-9.2	-25.1
Apparel	23	076	1,354.2	1,364.6	1,288.7	.8	-4.8

SOURCES: Bureau of Labor Statistics and National Science Foundation.

period of time,⁴ it is possible to use the results of this survey for estimating changes in SE&T requirements in manufacturing industries without surveying the sector every year. By applying the percentage distribution of the occupational mix in the base period to current estimates of industry employment,⁵ updated estimates of occupational employment may be obtained. For example,

the electrical equipment industry in 1977 utilized scientists at a rate of 0.67 percent of total employment, engineers at a rate of 6.71 percent, and technicians at a 5.45 percent rate. Applying these percentages to a reported employment level of 2,018,000 in November 1978,⁶ it is estimated that 135,000 engineers, 14,000 scientists, and 110,000 technicians were employed in this industry in that month. Expanding this procedure to the entire manufacturing sector, it is estimated that November 1978 employment of scientists, engineers, and technicians was about 6 percent higher than average annual 1977 employment. The growth was about 7 percent for both engineers and technicians, and around 4 percent for scientists. It should be noted that the validity of the assumptions underlying this analysis will not be empirically verifiable until data from another manufacturing survey become available.

⁴ Department of Labor, Bureau of Labor Statistics, *Tomorrow's Manpower Needs. Research Report on Manpower Projection Methods*, Bulletin 1769 (Washington, D.C., 1973). This report concludes that about one-half the change in occupational employment over the 10-year period 1960-70 is accounted for by changes in industry employment. If the change in skill-mix is assumed to occur at a constant rate, and if the change for SE&T occupations is assumed to occur at the same rate as for those occupations reported on in the study, a method incorporating only the change in industrial mix will account for 95 percent of the change in SE&T occupational employment when using industrial employment data one year removed from the base period. Given these assumptions, the analysis reported in the text probably accounts for over 90 percent of the actual change in SE&T employment in manufacturing for the period between 1977 and November 1978.

⁵ Department of Labor, Bureau of Labor Statistics, *Employment and Earnings* (monthly) (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office).

⁶ *Ibid.*, December 1978.

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